1. See six plots below.

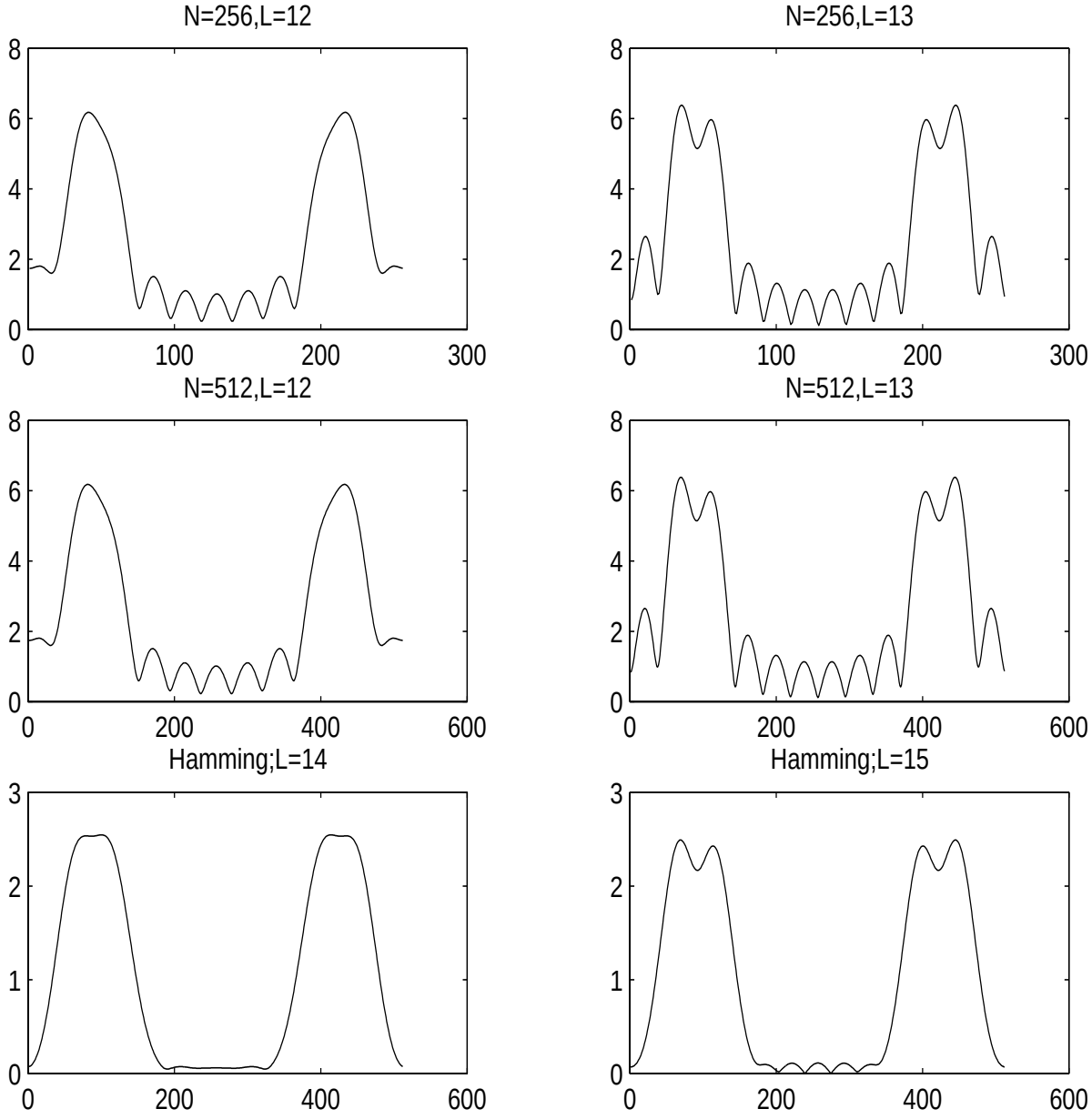
1a. With no window, L=$\boxed{13}$ is needed to resolve the two peaks.

1b. $|\omega_1 - \omega_2| > \frac{2\pi}{L} \rightarrow L > \frac{2\pi}{0.4\pi - 0.3\pi} = \boxed{20}$. Note this is quite conservative here.

1c. Increasing N from 256 to 512 makes no visible difference.

1d. With a window, L=$\boxed{15}$ is needed to resolve the two peaks.

1e. Increasing L helps; increasing N doesn't help; using a window hurts.



2. See first two plots below.

2a. The smallest peak is lost in the sidelobes. (2b) Now you can see all four peaks.

2c. Peaks occur at Matlab indices 37, 70, 81.5, 94.5. This gives frequency estimates: (37-1)$\frac{1000}{256}$=141; (70-1)$\frac{1000}{256}$=270; (81.5-1)$\frac{1000}{256}$=314; (94.5-1)$\frac{1000}{256}$=365. Pretty close!

3a. Sounds like a calliope, but it is actually tonal (pure sinusoidal) versions of the U-M and MSU fight songs added together. How do we get rid of MSU?

3b. See below. (3c) Now we can see they occupy different frequency bands.

3d. `FX2=fft(X2);FX2(6501:78002-6501)=0;Y=real(ifft(FX2));` See below.